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Network Simulation Tools for Prototyping Scalable P2P Applications

NATO IST RTG-12 WORKSHOP

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On- going work with SRSS group (Brian Adamson & Rick Jones)

Navy Research Lab, Washington DC

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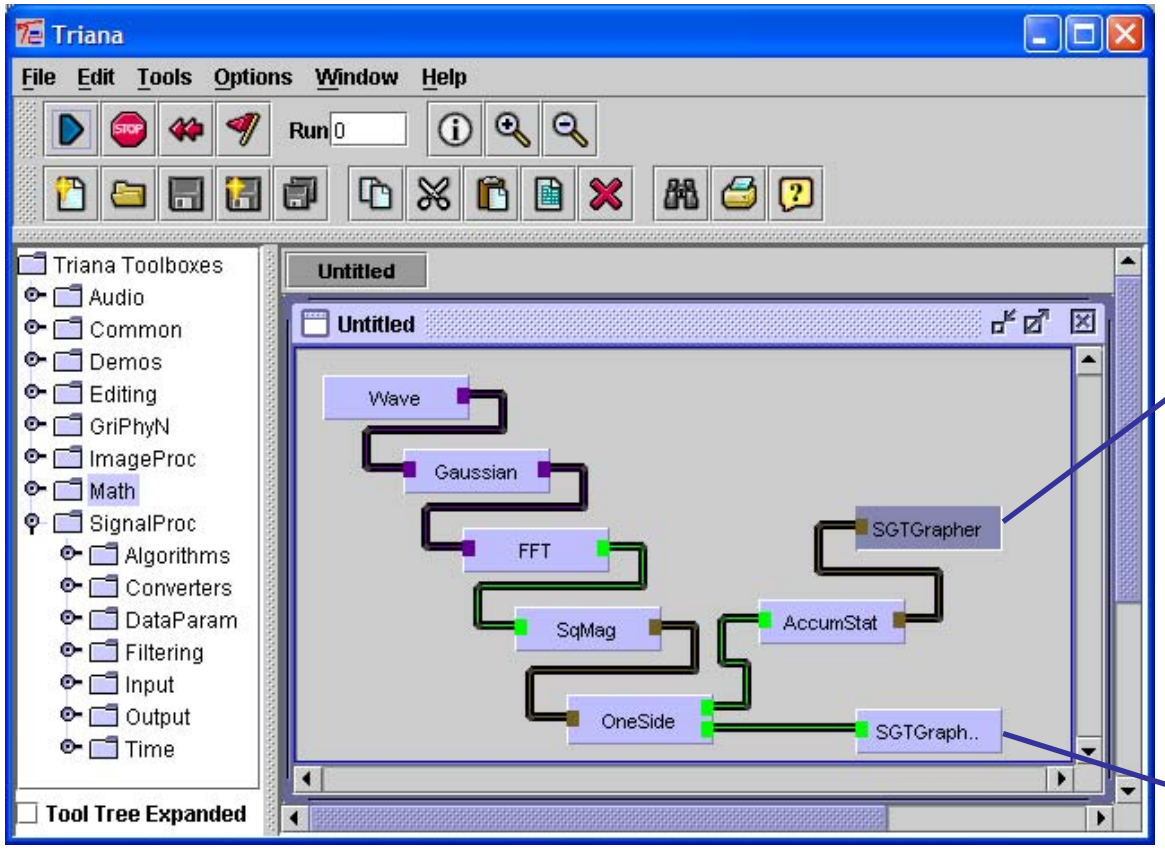
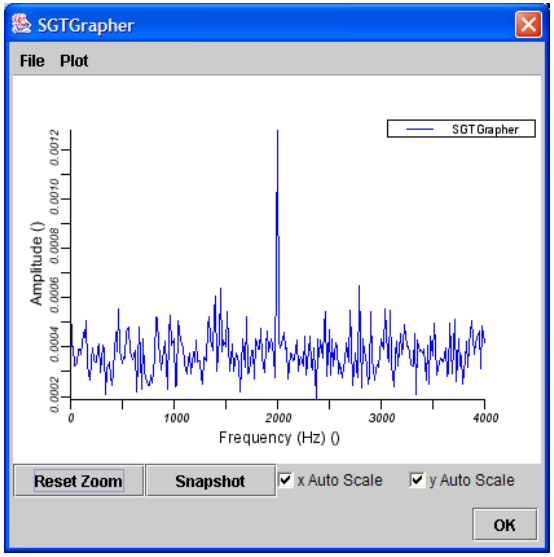
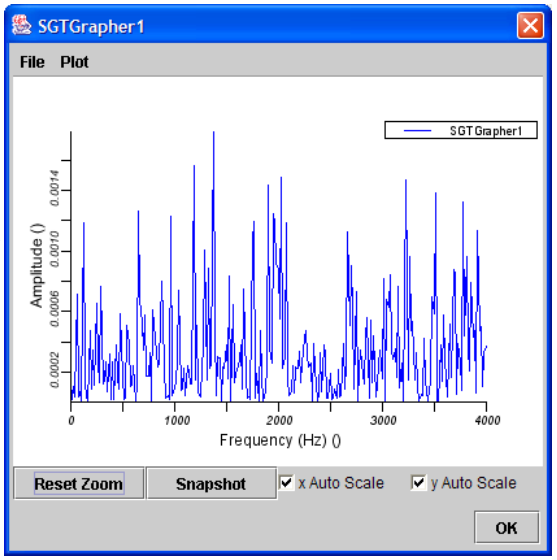
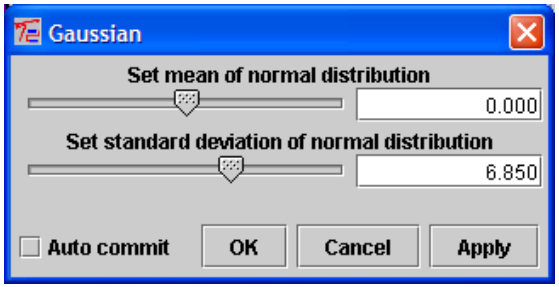
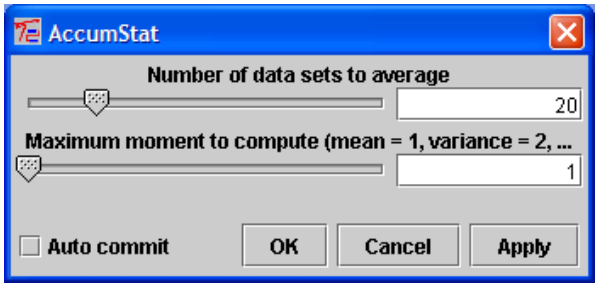
Cardiff Triana Project



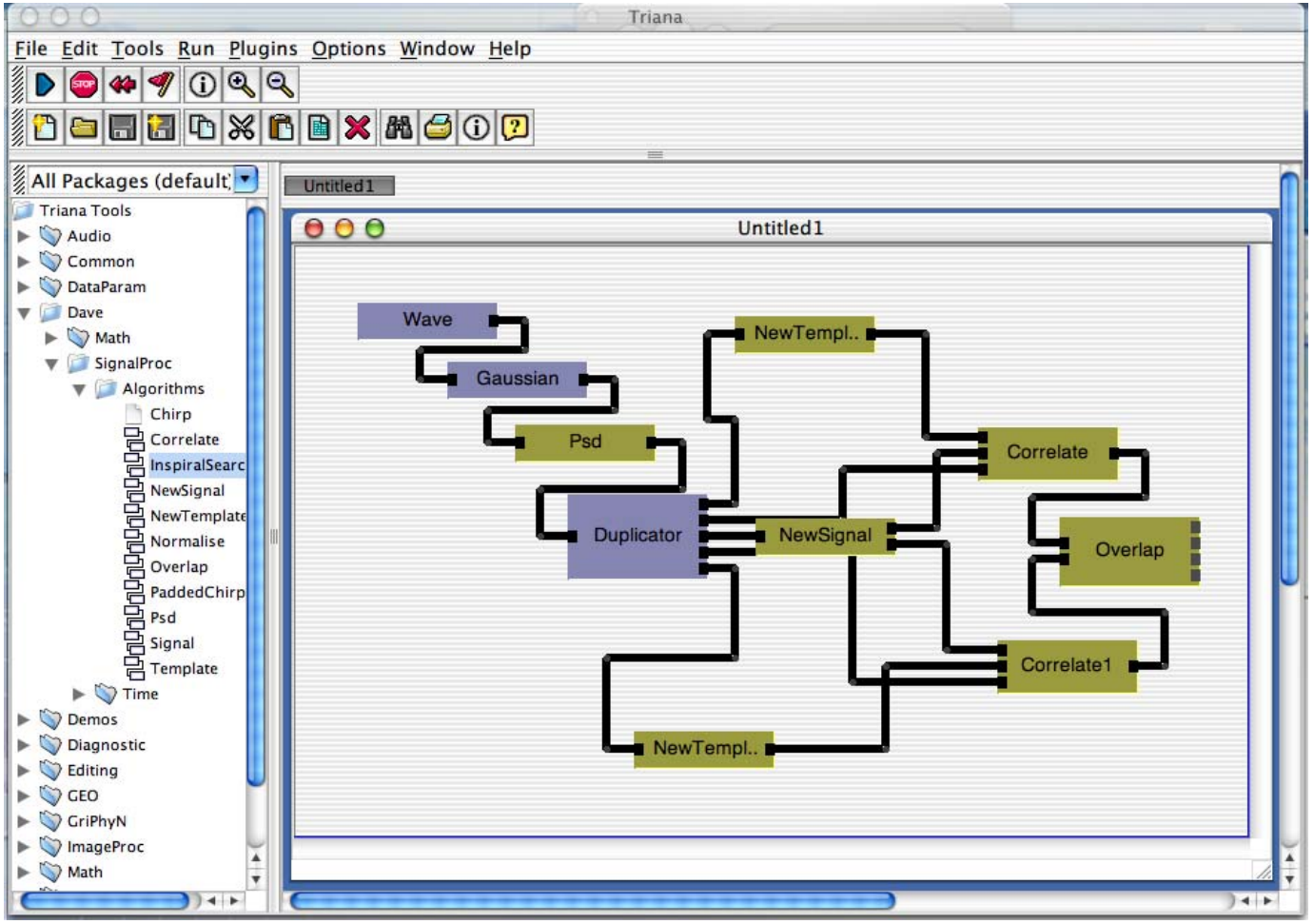


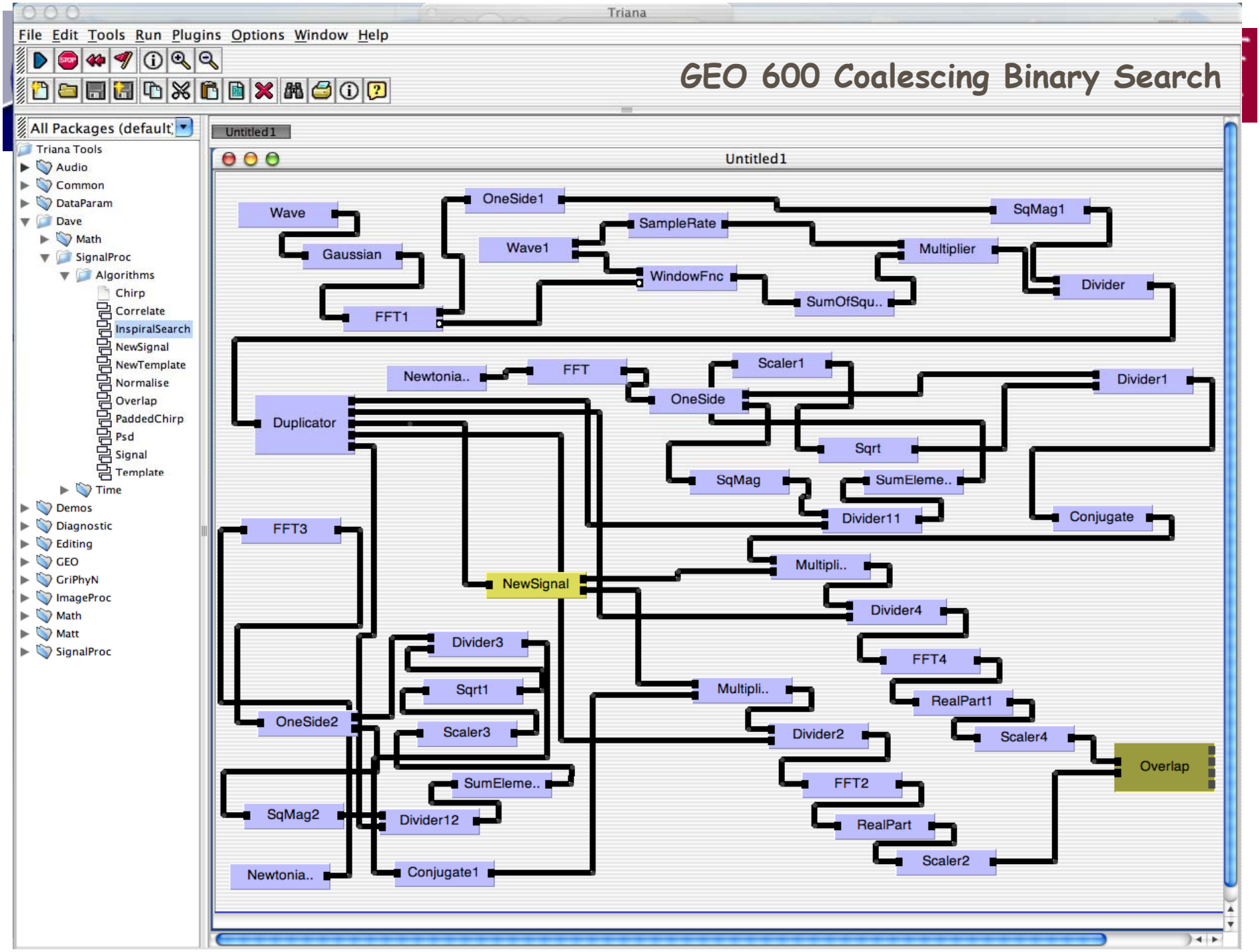






Coalescing Binary Search




Triana
File Edit Tools Run Plugins Options Window Help
GEO 600 Coalescing Binary Search
All Packages (default)
Triana Tools
Audio
Common
DataParam
Dave
Math
SignalProc
Algorithms
Chirp
Correlate
InspiralSearch
NewSignal
NewTemplate
Normalise
Overlap
PaddedChirp
Psd
Signal
Template
Time
Demos
Diagnostic
Editing
GEO
GriPhyN
ImageProc
Math
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SignalProc
Untitled1
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Wave
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Newtonia..
FFT
OneSide
Scaler1
Divider1
Duplicator
Sqrt
SqMag
SumEleme..
Divider11
Conjugate
FFT3
NewSignal
Multipli..
Divider4
FFT4
RealPart1
Scaler4
Overlap
Divider3
Sqrt1
OneSide2
Scaler3
Multipli..
Divider2
FFT2
RealPart
Scaler2
SumEleme..
SqMag2
Divider12
Newtonia..
Conjugate1

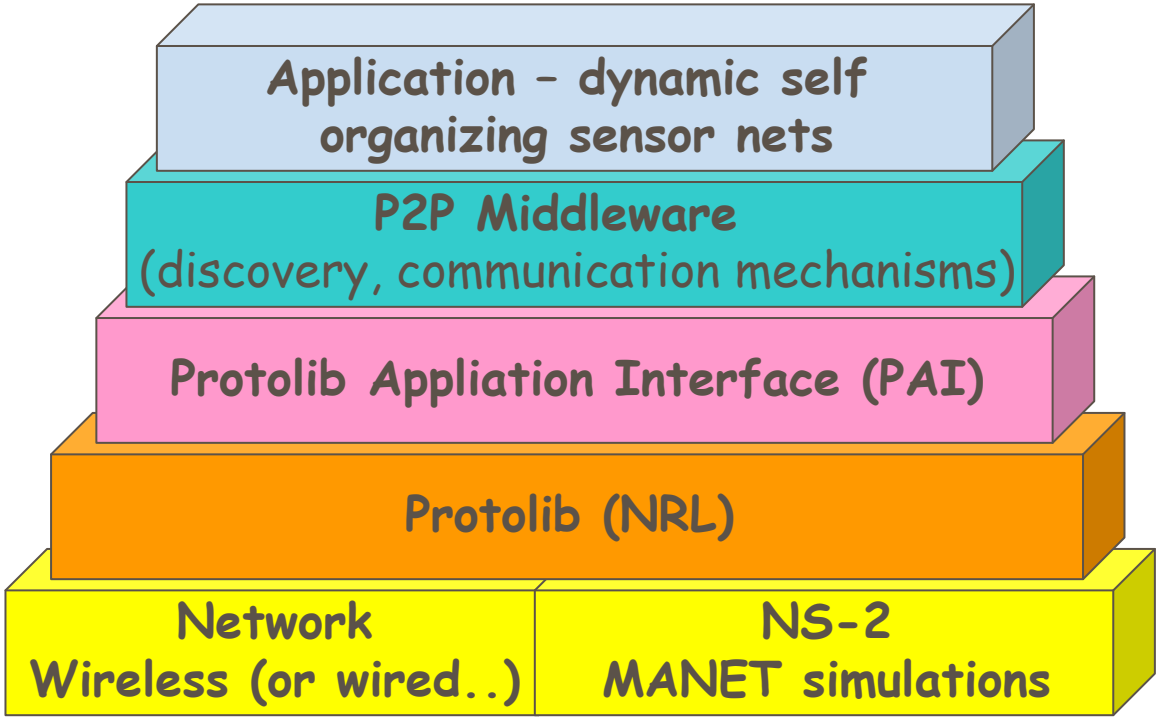
SRSS Project

Stands for …

Scalable Robust Self-organizing Sensors …

- Simulate mobile sensor networks using NS-2
- Investigate Publish/subscribe/P2P discovery mechanisms e.g. Unicast, Multicast etc
- Conduct simulations to trade-off performance of application-level and/or network level discovery mechanisms in sensor environment.
- Running within MANET networks - wireless connectivity
- For NS-2, this involves:
  - Integrating data transmission between NS-2 nodes (via Protolib)
  - Building infrastructure to allow different middleware to be easily integrated into this architecture.

Overview of SRSS Architecture

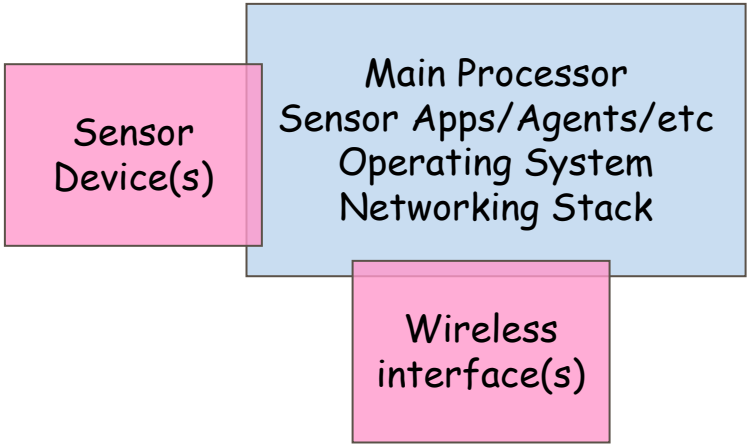


The SRSS Environment

- What is MANET ?
  - Mobile Ad hoc Networks
  - Wireless transmission
  - No centralized administration / control
  - No existing network infrastructure
  - A node can be a source, a sink or a transit
  - All nodes participate in the discovery of a route
- Applications
  - Cooperative mobile data exchange
  - Rapidly deployable communication with efficient networking
  - Communication where no infrastructure exists

and the sensors

...



•Flexible for experimentation, but demonstration-worthy form factor.
•Linux on PC-104 or similar platform is a likely candidate.

NS-2: A Network Simulator

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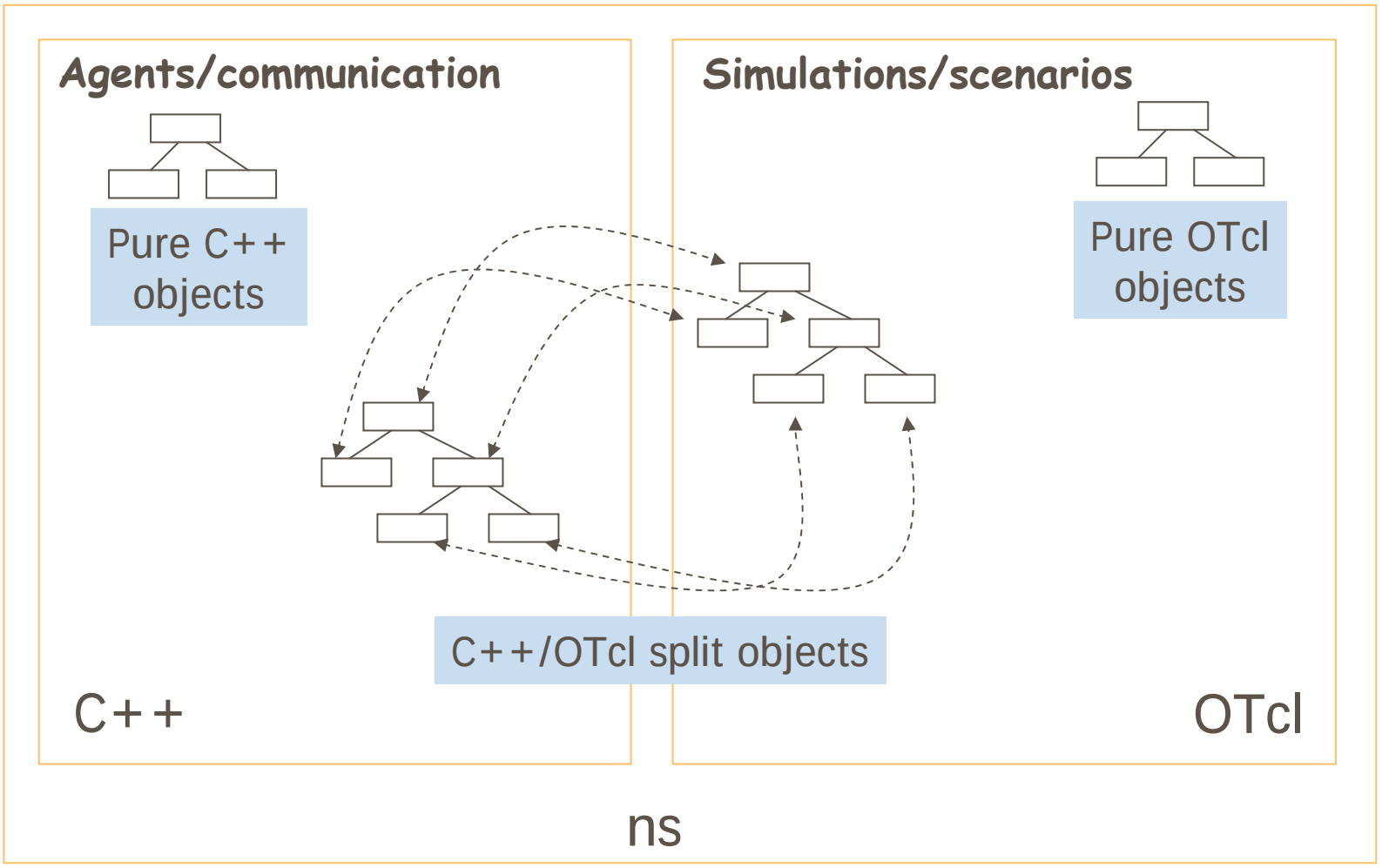
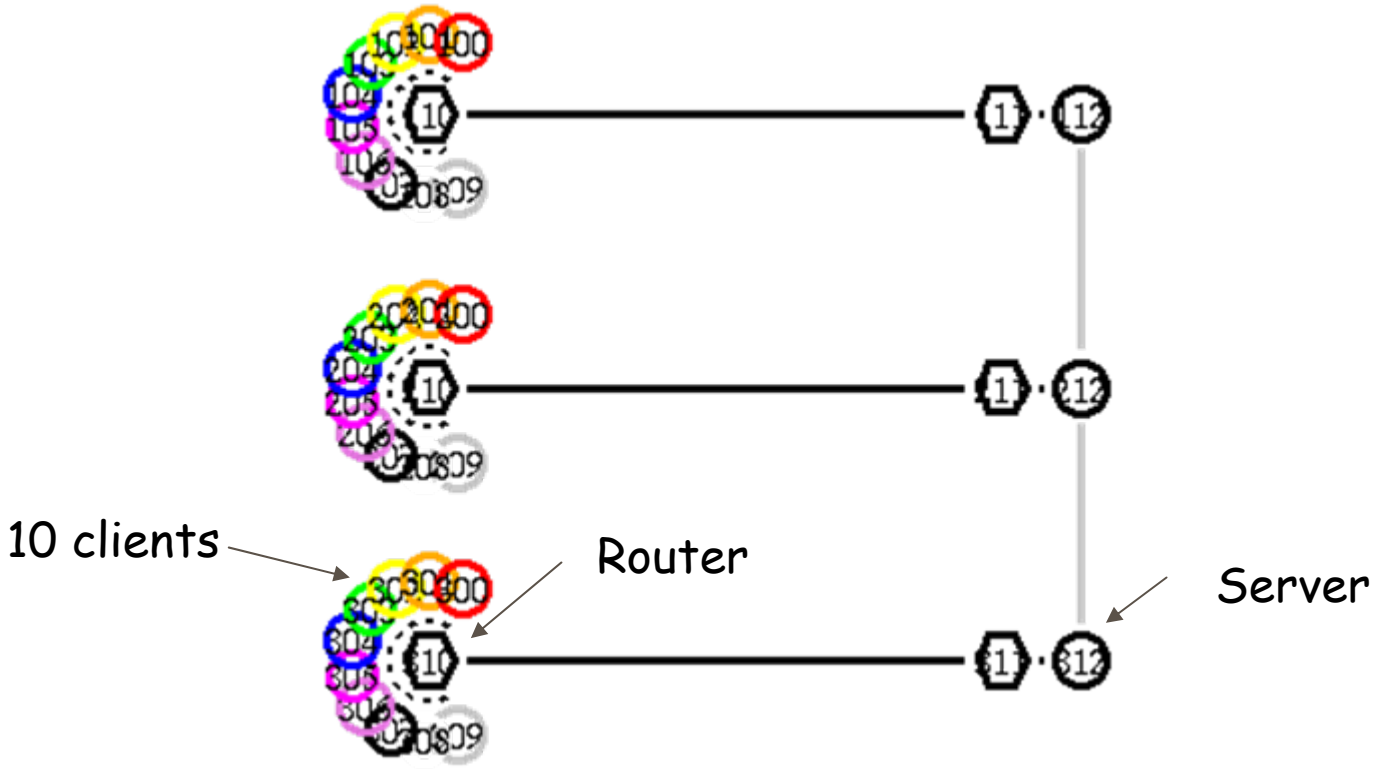
- Discrete event simulator
- Packet-level
- Link layer and up
  - i.e. network, transport, session, presentation and application
- Wired and wireless simulations
- Platforms
  - Most UNIX and UNIX-like systems
  - Window 95/98/NT
  - (Emulation only for FreeBSD for now)

NS-2: OTcl and C++



NAM - Example

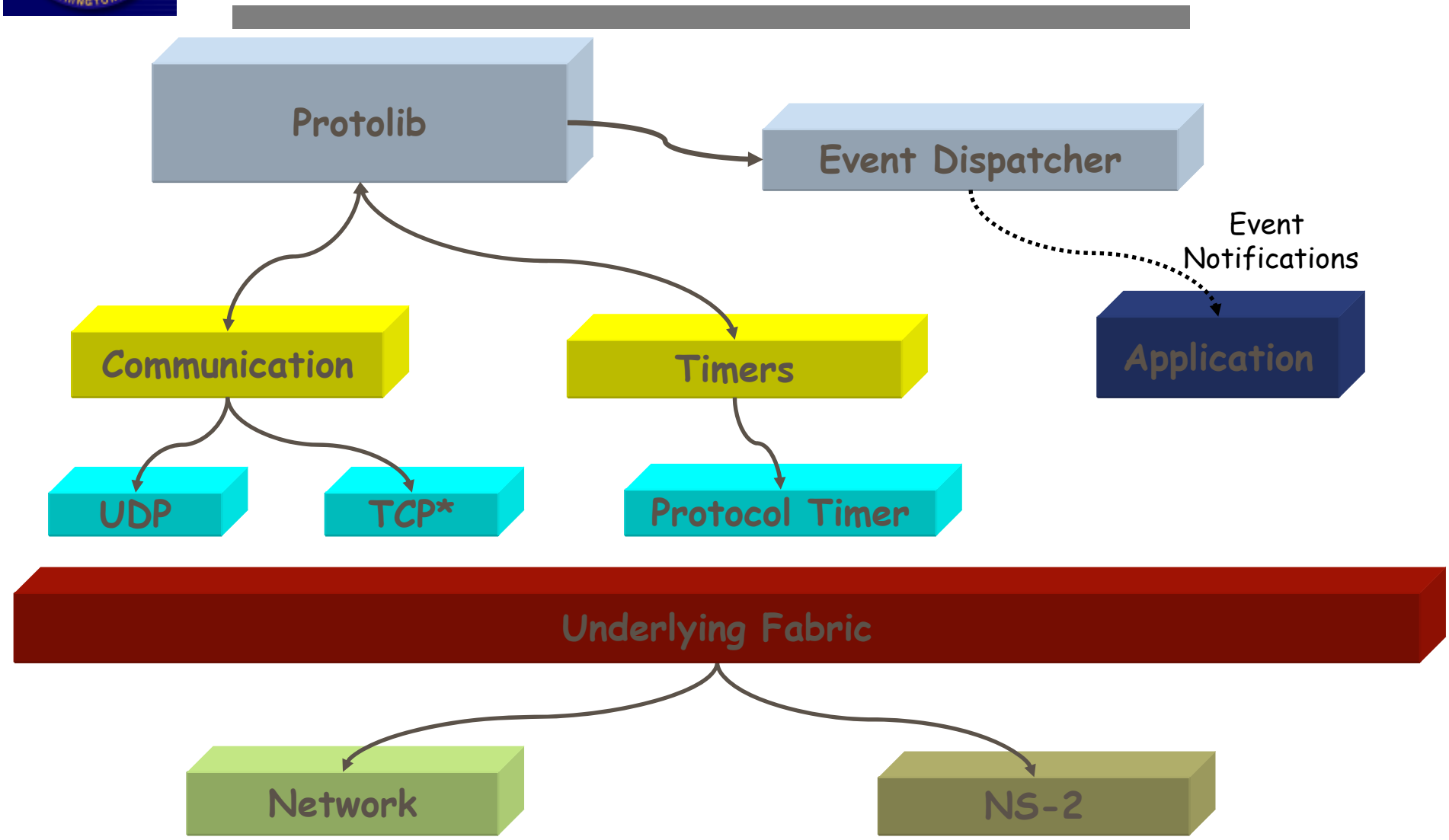


- Three TCP slow-start restart algorithms
- Test - improving restart of idle TCP connections

Protolib - Brian Adamson and Joe Macker, NRL

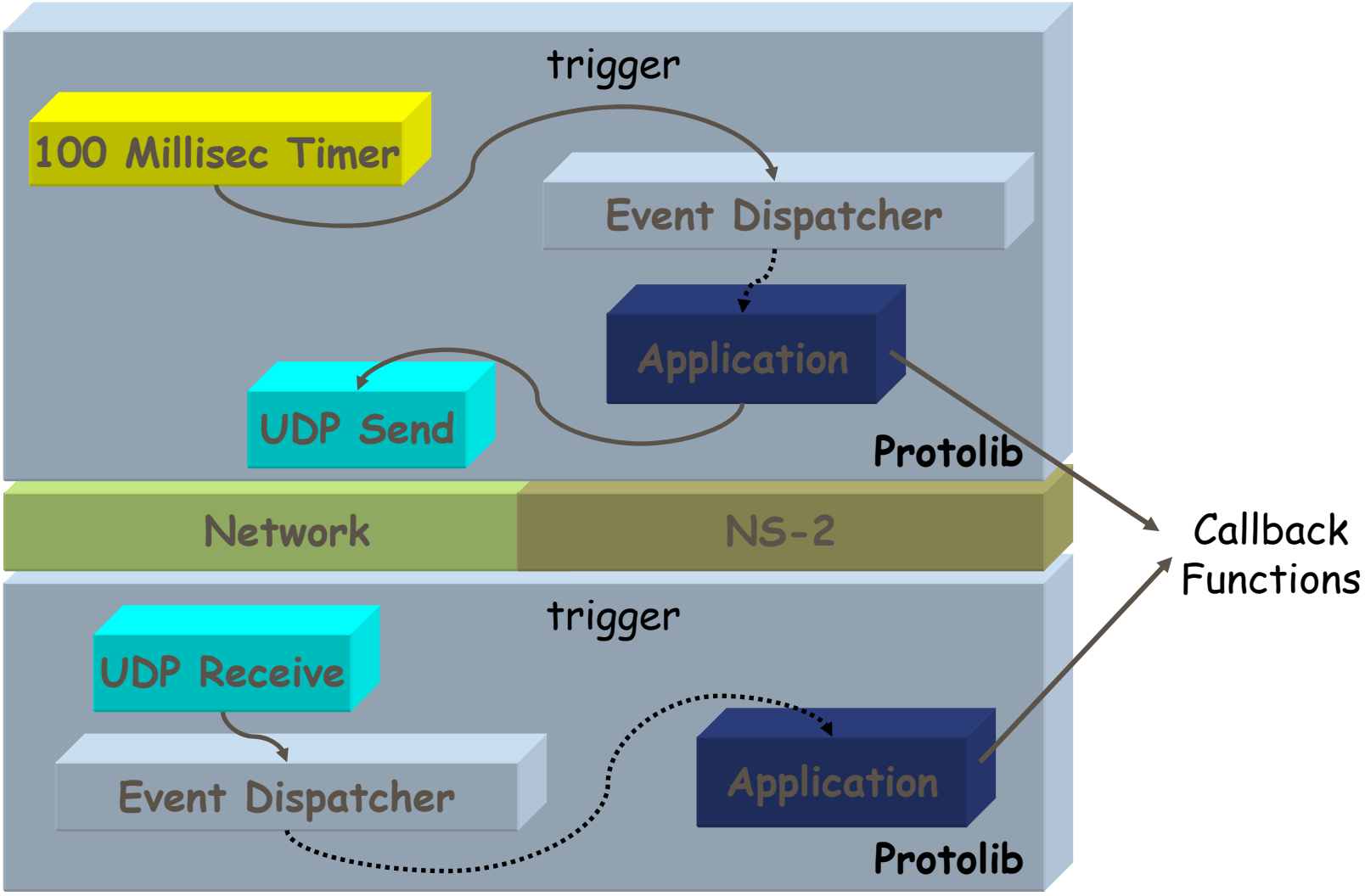
- Protocol Prototyping library (ProtoLib) - C++ class library
- Cross-platform – works on Windows and Unix using native implementations
- Provides networking capabilities –
  - Currently supports UDP communication
    - Unicast and Multicast
  - Communication works across networks or between NS-2 nodes, by:
    - overriding basic NS-2 UDP protocol implementation
    - can communicate data across NS2 nodes
    - Can simulate real networked applications passing real data
    - We are doing this for the P2P world ..

Protolib Overview



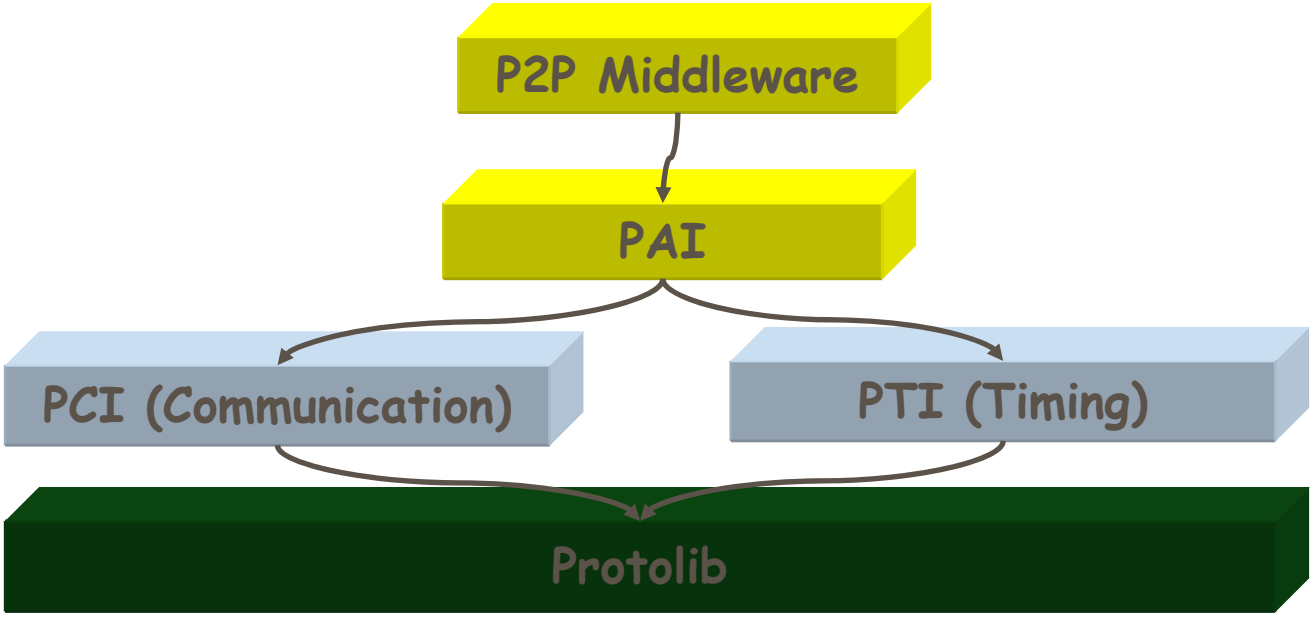
(*) Will be implemented next phase

Simple Protolib Scenario

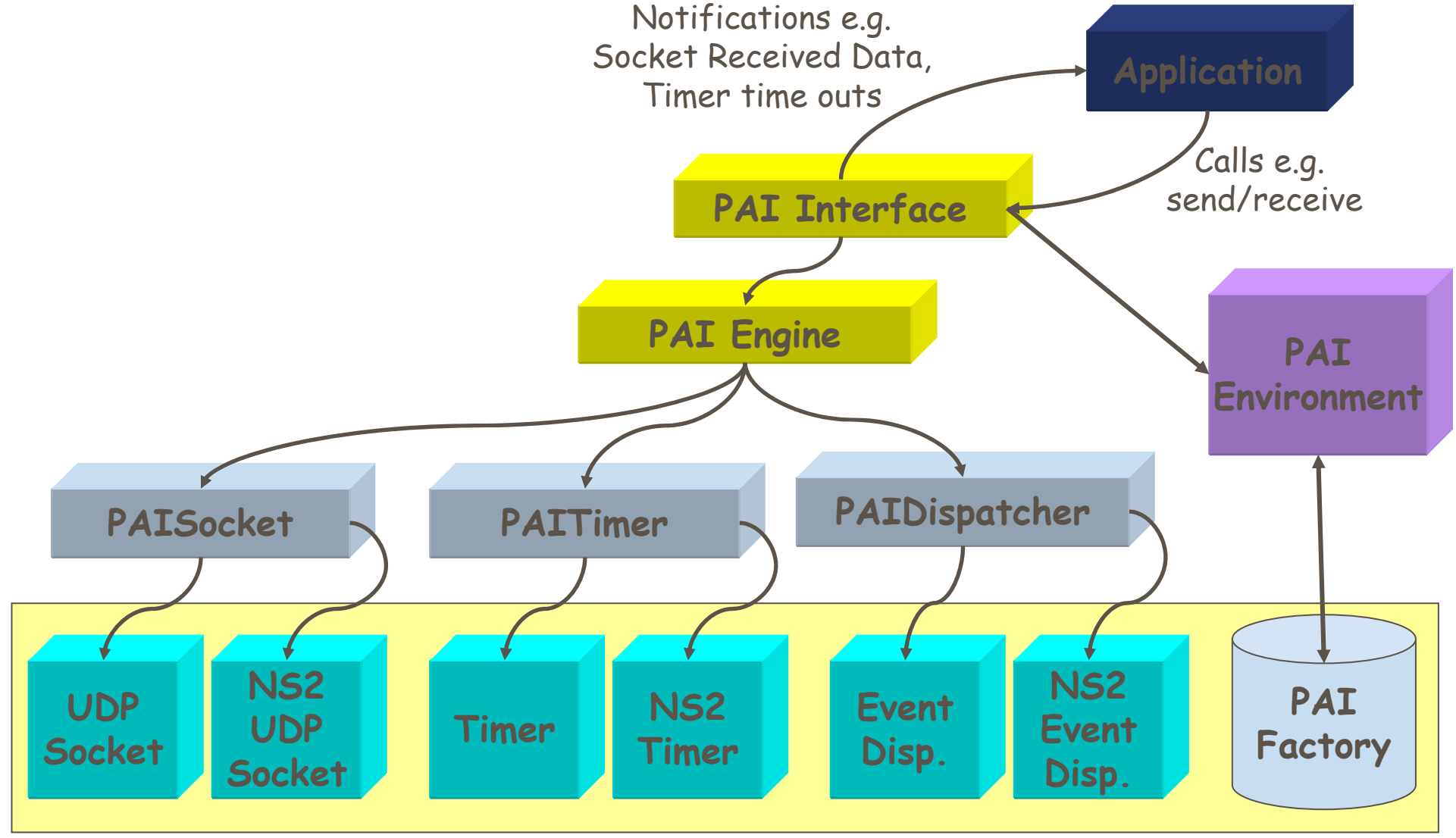


Protolib Application Interface (PAI)

- Abstracts reliance on specific networking/timing mechanisms in Protolib/others
  - Middleware/Applications use PAI and change environment to choose configuration e.g. Network or NS-2 etc
  - Provides generic classes for creating sockets/timers
  - Support multiple sockets/timers + listeners e.g. for timeouts or UDP receive data events – multithreaded event dispatching
  - Provides a concise C++ interface for Java JNI integration



PAI Structure, Factory Method Design



PAI Example

When Timer times out:

```
void PAI_Example::OnTxTimeout() {
…..
    pci->send(sock1, "127.0.0.1", buffer, len);
}
```

When Data is Received:

```
void PAI_Example::OnSocketRecv() {
 …..
    char *buf = pci->recv(sock1, &addr, &len);
}
```

Example Main Program:

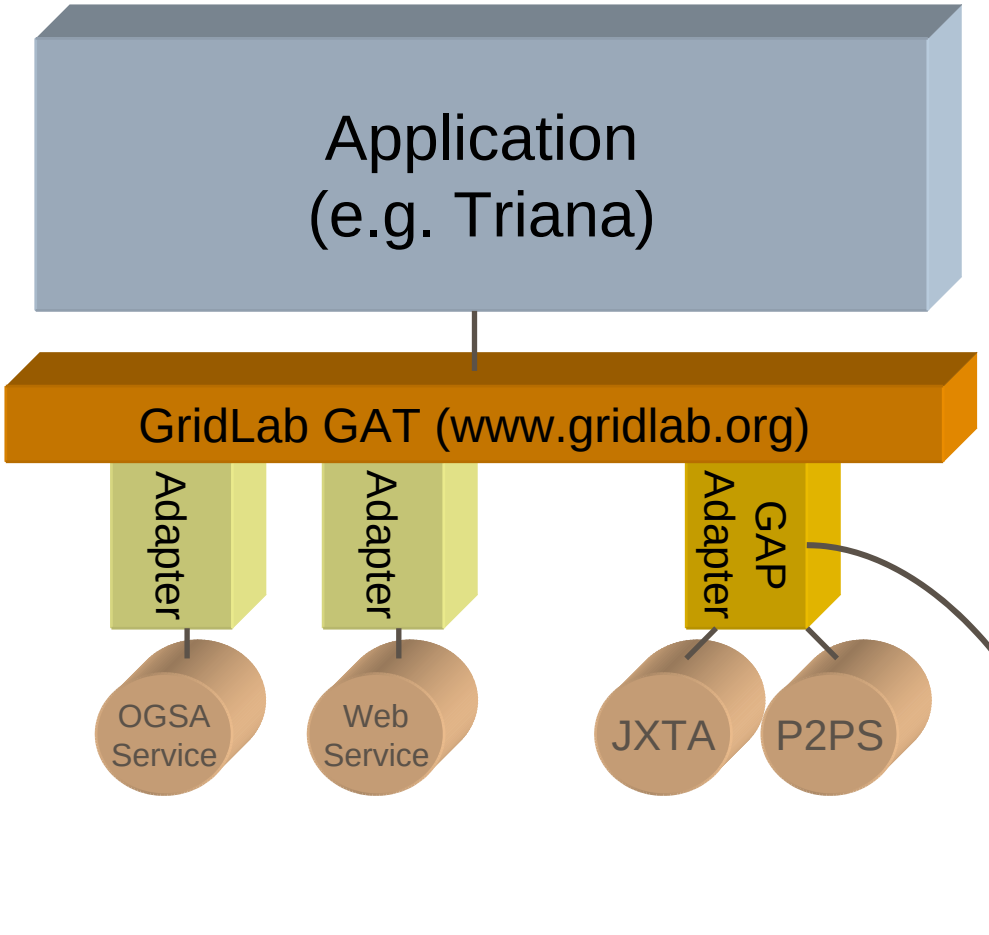
```
pai.getEnvironment()->setBinding(PAI_NETWORK);
pai.getEnvironment()->setNetworkProtocol(PAI_UDP);

timer = pti->addTimer(1.0, 5);
sock = pci->addSocket(5004);

pci->addListener(sock, this, (CallbackFunc)&PAI_Example::OnTxTimeout);
pti->addListener(timer, this, (CallbackFunc)&PAI_Example::OnSocketRecv);

pti->runTimers();
```

P2P Middleware

- P2P Middleware Requirements?
  - Dynamic Discovery Mechanisms e.g. Unicast, Multicast
  - Communication – support different transport protocols UDP, TCP etc
  - Lightweight

- P2P: Which middleware to use?
  - First promising choice: JXTA – Summer 2002
  - Problems:
    - Lightweight ? Only by limiting functionality on Edge peers
    - Scalability problems – discovering multiple pipes unreliable in tests
    - Difficult to extend code base
      - JXTA uses *Endpoint* Implementations to represent different network communication protocols e.g. TCP, Bluetooth etc BUT:
      - Different implementation for discovery –complex to plug in new layer

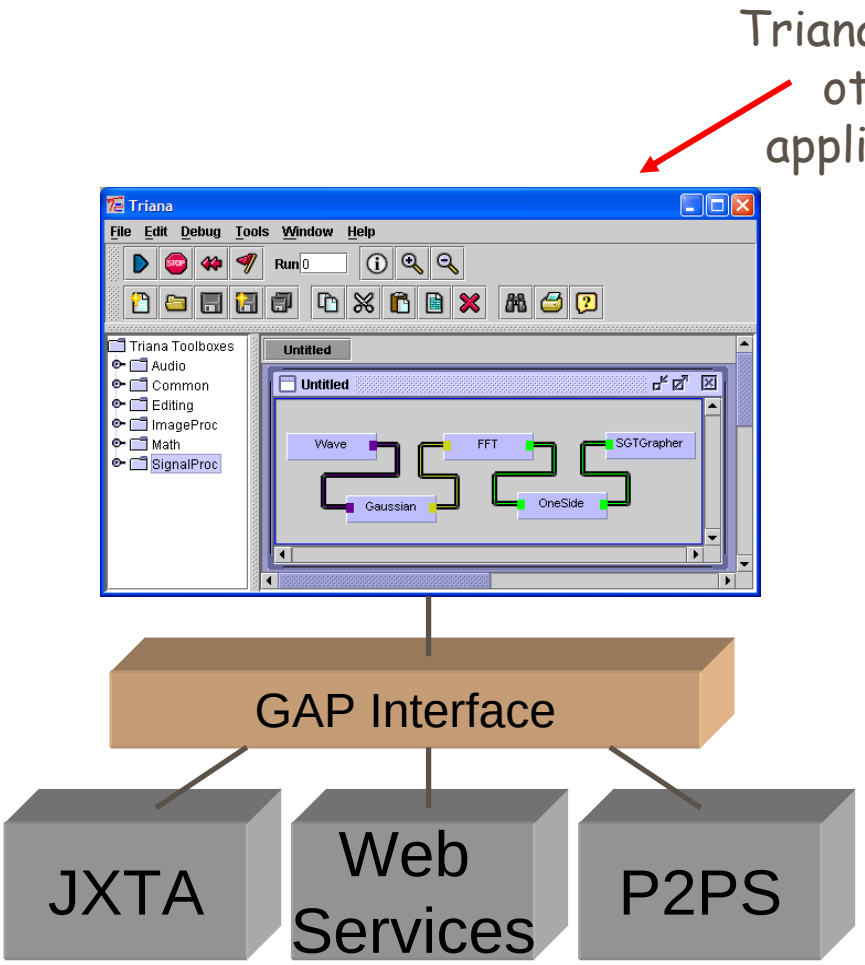
Gridlab GAT Architecture



GAP is our P2P Application-level Interface

Triana and the GAP Interface

- Interface between Application and Peer-to-Peer Middleware
  - Provides an insulation layer for P2P applications
- loosely coupled, dynamically late bound modules
- Simple
- Generic
  - Not Triana Specific
  - Contains common calls e.g. advertise_service, discover_service, create_pipe etc



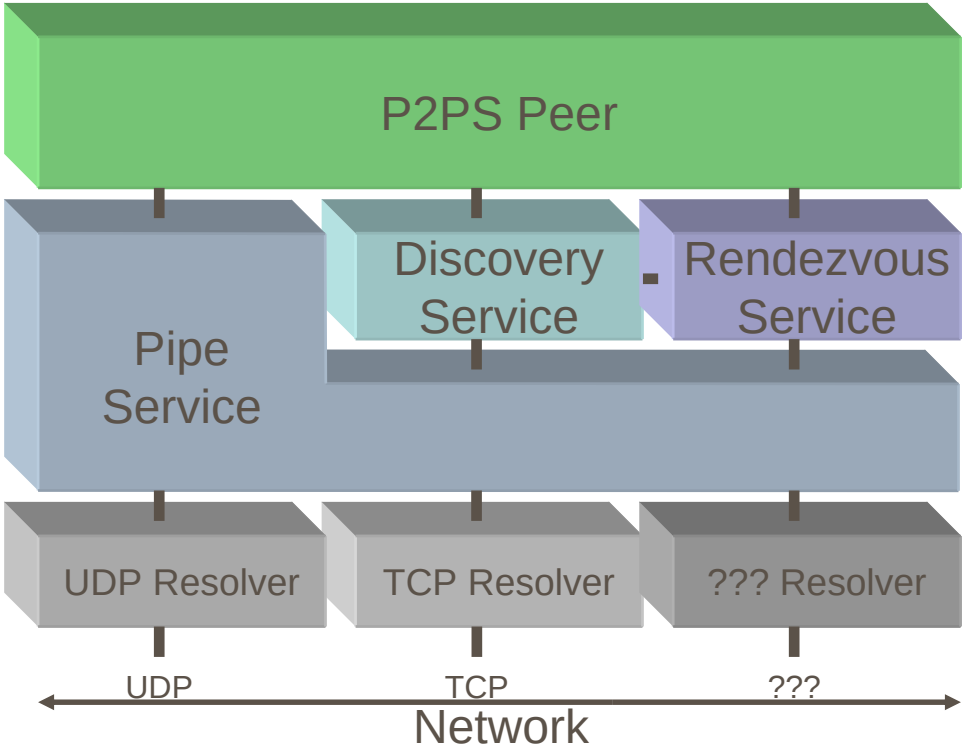
For more info on Triana Distributed Implementation, see www.trianacode.org

P2PS – Dr Ian Wang, Cardiff

- Lightweight P2P Middleware:
  - Language independent specification –
    - reference implementation is in Java – C++ version in planning
    - Communication is language independent – use XML adverts and data structures
  - Pluggable transport layer – currently implemented UDP, TCP/IP
    - Dynamic Discovery – using Unicast and Multicast
    - Factory design, using resolvers
  - Decentralized structure
  - Uses Rendezvous nodes (self nominated) for caching adverts/data
    - (centralized-decentralized) network structure for scalability
  - Implements Relays - traversing firewalls
  - 1/100th size of JXTA …
  - Release (www.trianacode.org) soon .. for open source development

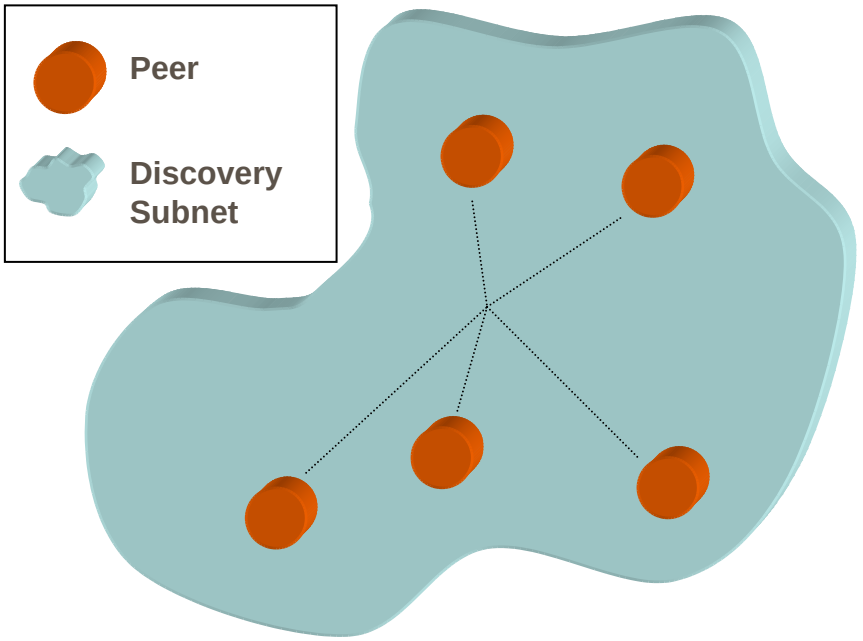
P2PS Architecture

- Discovery Service
  - Broadcast/locate adverts + queries in discovery subnet
- Pipe Service
  - Connect pipes using endpoint resolvers
- Rendezvous Service
  - Send/receive queries from known rendezvous peers



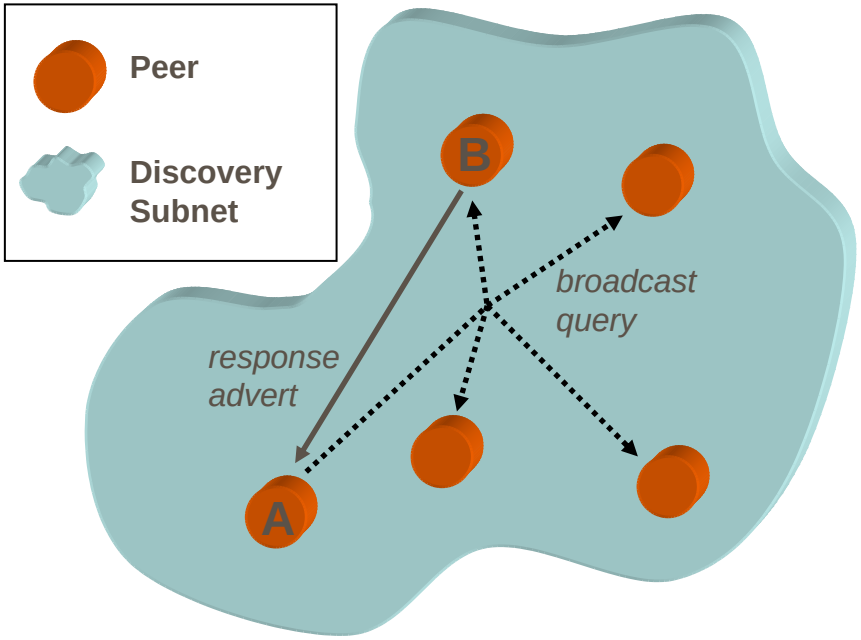
Discovery Service

- All peers have Discovery Services
- Caches local adverts + queries
- Broadcast adverts + queries to all peers in its discovery subnet
- Responds to received adverts + queries
- Discovery subnet scope determined by resolvers
  - e.g. UDP Multicast scope



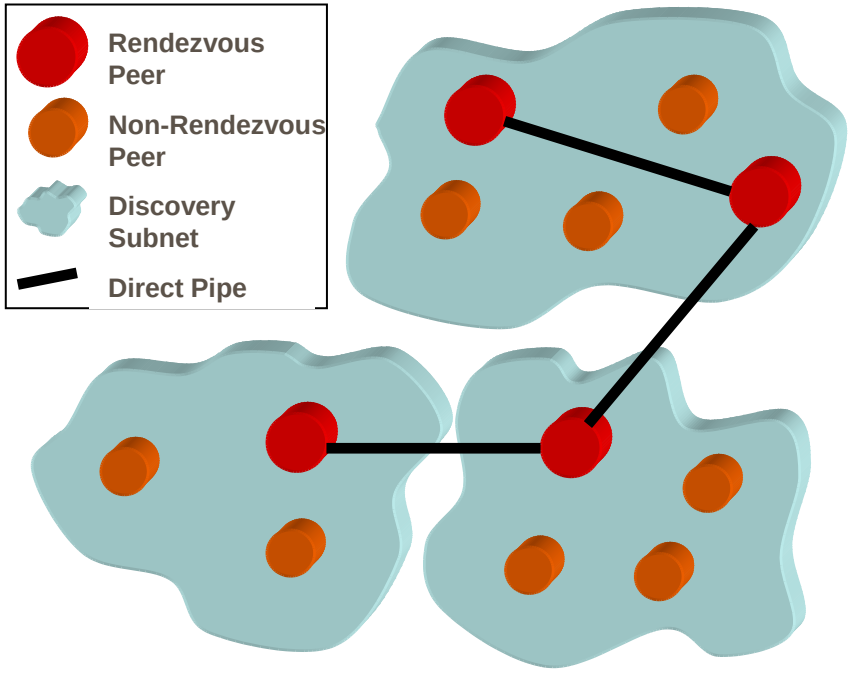
Discovery Service Scenario

1. Peer A creates pipe
   - Broadcasts advert
   - Caches advert locally (not cached at Peer B)
2. Peer B queries for all pipes
   - Broadcasts query
3. Peer A receives query
   - Matches query with locally cached pipe advert
   - Sends pipe advert direct to Peer B
4. Peer B discovers pipe

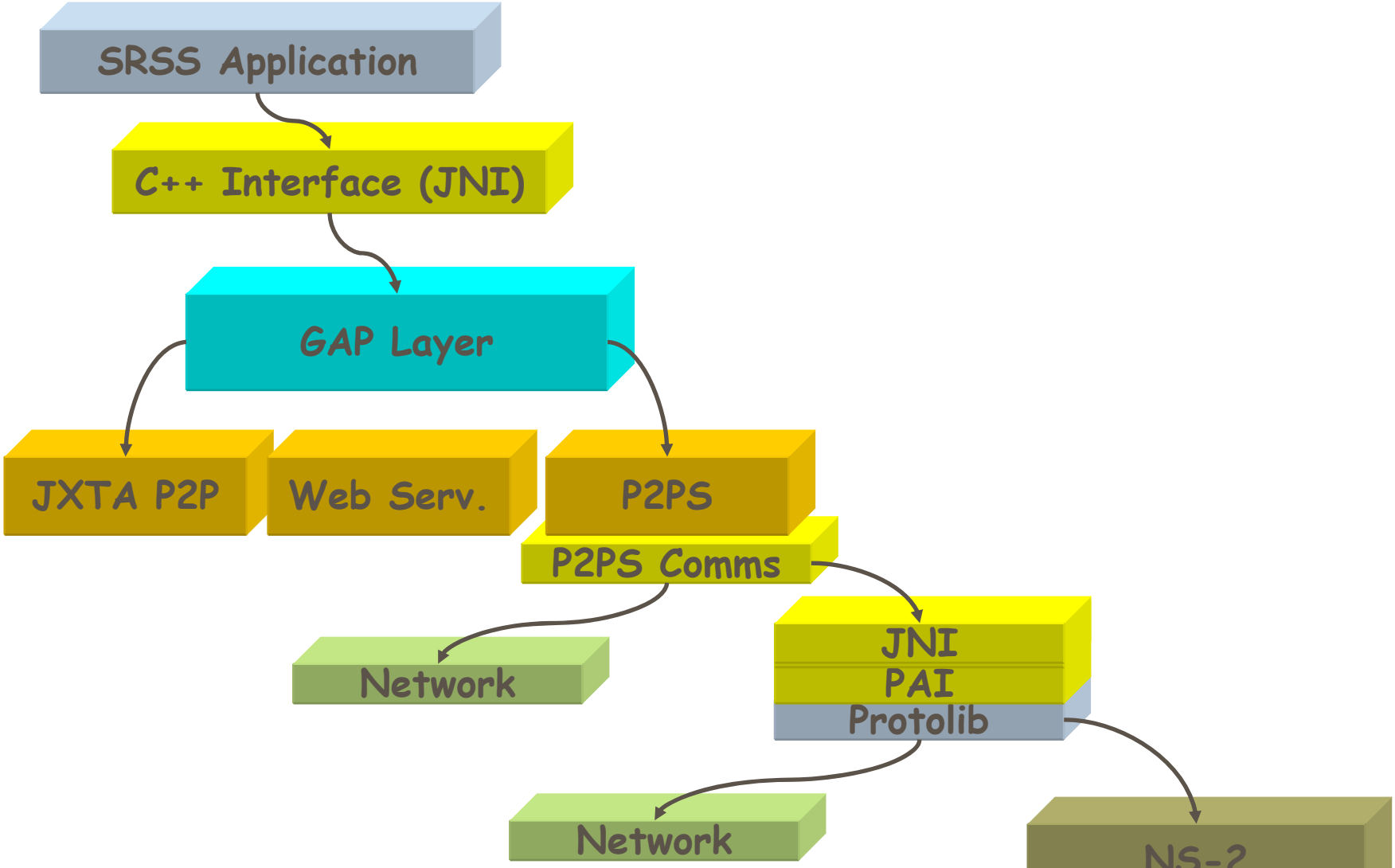


Rendezvous Service

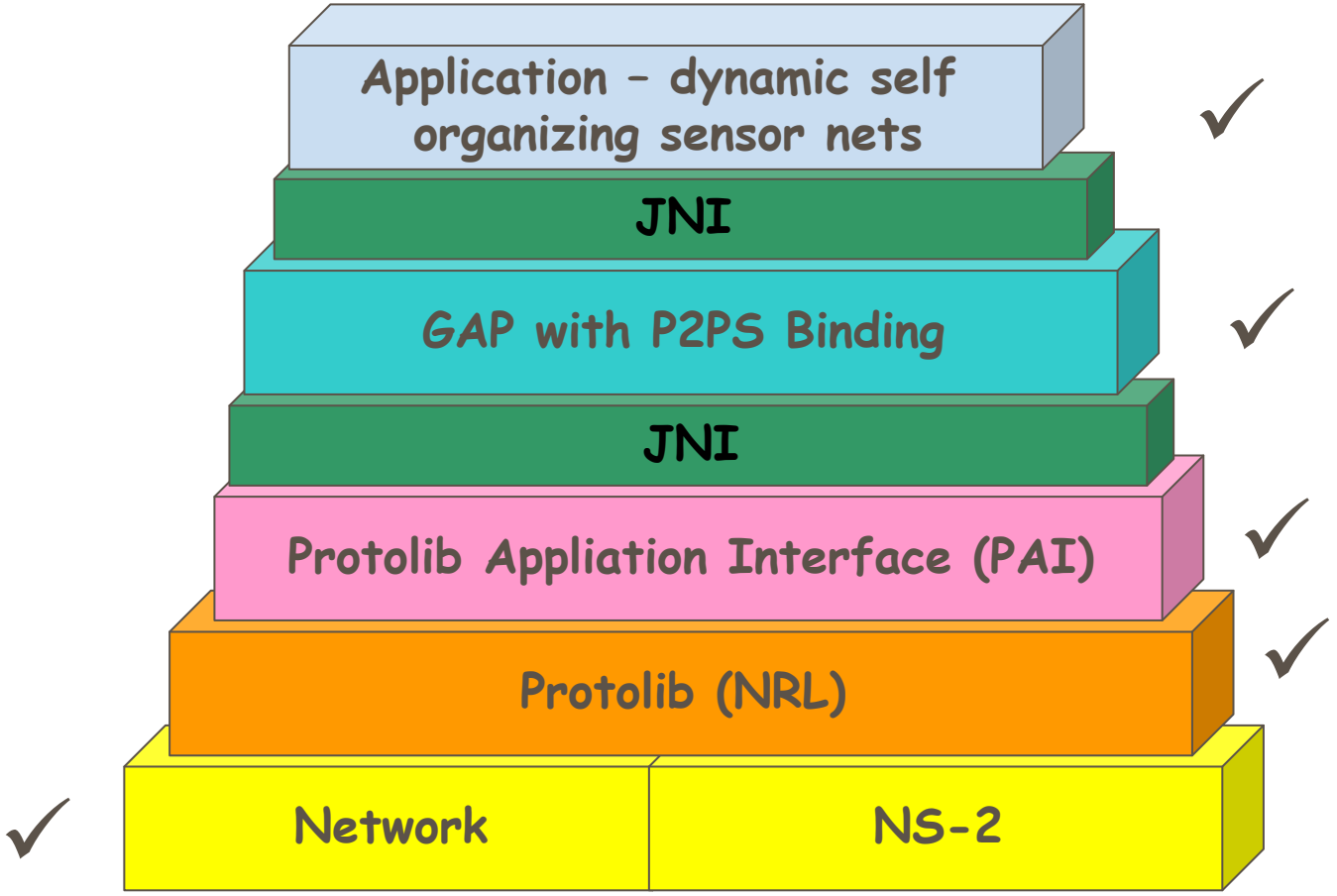
- Peers can optionally become rendezvous peers
- Direct pipe connections to other rendezvous peers
  - usually in other discovery subnets
- Cache all received adverts + queries
- Forward queries to known rendezvous peers
  - Note: Adverts are not forwarded outside discovery subnet



NS-2 GAP Integration



Status Of Implementation



Scenarios and Conclusions

- Resulting system has many applications/uses:
  - Mobile Sensors – test discovery in simulated dynamically changing environments.
  - Triana – simulate P2P environment – see if P2P middleware actually scales without having to run Triana on 1000's of nodes …
- The new GAT/GAP EU proposal – The P2P Gap interface will be generalized further in Gridlab2 with input from applications – NRL, GW@Home (AIP) and ..